CAEN
Tools for Discovery

CAEN EDUCATIONAL
edu.caen.it



HANDBOOK OF EXPERIMENTS

SG6011A Silicon Photomultiplier (SiPM)

SiPM Characterization

Particle Detector Characterization

EDUCATIONAL KIT

SP5600E

CAEN S.p.A. · Via Vetraia 11, 55049 Viareggio (LU) Italy · www.caen.it — © 2026 CAEN S.p.A. All rights reserved.
Specifications are subject to change without notice.

CAEN EDUCATIONAL · SG6011A

SiPM Characterization

Categories: CAEN Experiments, Particle Detector Characterization | Tags: Application Notes, EN, SiPM, SiPM Characterization, University of Insubria

Difficult	Execution Time	Data Analysis	Radioactive Sources
		Yes	No

Hardware setup

This experiment guide is referred to the **SP5600E** educational kit.

Equipment: SP5600 – Educational Photon Kit

Model	SP5600	DT5720A	SP5601	SP5650C
Description	Power Supply and Application Unit	Desktop Digitizer 250 MS/s	LED Driver	Sensor Holder for SP5600 with SiPM

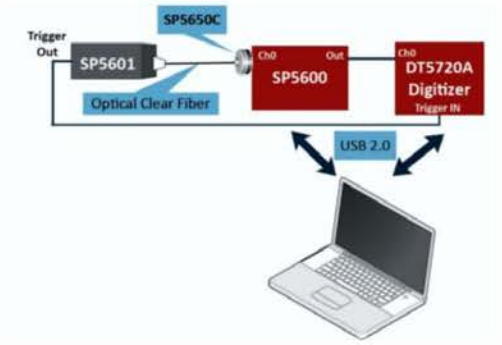
Purpose of the experiment

Characterization of a SiPM detector using an ultra-fast pulsed LED.
Estimation of the main features of the detector at fixed bias voltage.

Fundamentals

Silicon Photomultipliers (SiPM) consist of a high-density (up to ~10^4/mm^2) matrix of diodes connected in parallel on a common Si substrate. Each diode is an Avalanche Photo Diode (APD) operated in a limited Geiger-Müller regime connected in series with a quenching resistor, in order to achieve gain at level of ~10^6. As a consequence, these detectors are sensitive to single photons (even at room temperature) feature a dynamic range well above 100 photons/burst and have a high Photon Detection Efficiency (PDE) up to 50%. SiPM measure the light intensity simply by the number of fired cells. However, this information is affected and biased by stochastic effects characteristic of the sensor and occurring within the time window: spurious avalanches due to thermally generated carriers (a.k.a. Dark Counts), delayed avalanches associated to the release of carriers trapped in metastable states (a.k.a. Afterpulses) and an excess of fired cells due to photons produced in the primary avalanche, travelling in Silicon and triggering neighboring cells (a phenomenon called Optical Cross Talk). The typical SiPM response to a light pulse is characterized by multiple traces, each one corresponds to different numbers of fired cells, proportional to the number of impinging photons. Because of the high gain compared to the noise level, the traces are well separated, providing a photon number resolved detection of the light field.

Carrying out the experiment



Experimental setup block diagram

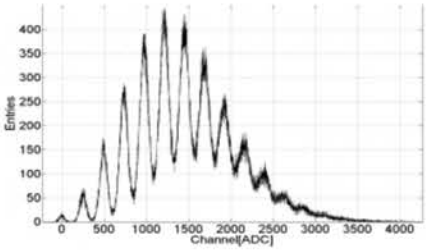
The light pulse from the SP5601 ultra-fast LED-Driver is driven through an optical clear fiber into the SP5650C SiPM holder housing the sensor under test and connected to the SP5600. The output signal (from the SP5600) is connected to the input channel of the DT5720A Desktop Digitizer equipped with the charge integration firmware, and triggered by the SP5601 LED-driver. The SP5600 and the DT5720A are connected to the PC through the USB. Use the default software values or optimize the bias voltage and discriminator threshold. The horizontal axis of the acquired spectrum is the ADC channels, therefore ADC channel conversion (ADC c.r.) factor can be calculated to perform the experiment and determine the main features of the SiPM.

Results

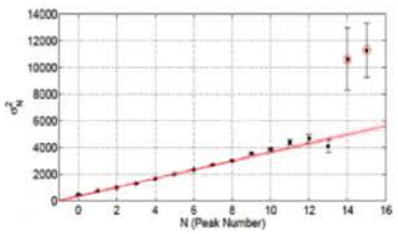
The gain of the SiPM is evaluated from the output charge of the sensor. After the estimation of the ADC channel conversion factor ($ADC_{c.r.}$) and the distance between adjacent peaks ($\Delta PP(ADC_{ch})$, the SiPM gain can be calculated according to the following equation:

$$Gain = [\Delta PP(ADC_{ch}) \times ADC_{c.r.}] / e$$

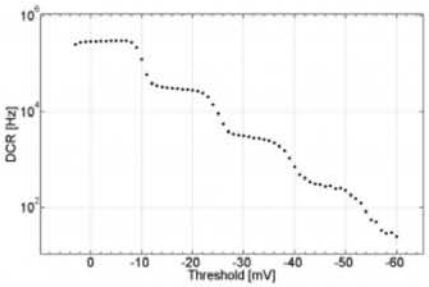
The resolution power of the system can be evaluated plotting the σ of each peaks versus the number of peaks. The counts frequency, in absence of light, at 0.5 p.e. threshold represents the DCR. The ratio between the dark count at 1.5 p.e. threshold ($DCR_{1.5}$) and the value at 0.5 p.e. threshold ($DCR_{0.5}$) give the crosstalk estimation of the detector.



Spectrum of Hamamatsu S10362-11-100C.



Peak σ versus peak number for Hamamatsu S10362-11-100C.



Sensor Dark Count frequency versus discrimination threshold

HEADQUARTERS

CAEN S.p.A.

Via Vetraia 11
55049 - Viareggio
Italy

Phone +39 0584 388 398
Fax +39 0584 388 959
info@caen.it
www.caen.it



WORLDWIDE

CAEN GmbH

Brunnenweg 9
64331 Weiterstadt
Germany
Phone +49 212 254 40 77
Fax +49 212 254 40 79
info@caen-de.com
www.caen-de.com

CAEN Technologies, Inc.

1 Edgewater Street - Suite 101
Staten Island, NY 10305
USA
Phone: +1 (718) 981-0401
Fax: +1 (718) 556-9185
info@caentechnologies.com
www.caentechnologies.com

CAENspa INDIA Private Limited

B205, BLDG42, B Wing,
Azad Nagar Sangam CHS,
Mhada Layout, Azad Nagar, Andheri (W)
Mumbai, Mumbai City,
Maharashtra, India, 400053
info@caen-india.in
www.caen-india.in

CAENsn SAS

Gare du Nord Business Centre 14,
Rue De Dunkerque
75010 Paris
France
info@caen-sn.fr
www.caen-sn.fr